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Female Students Who Succeed within Higher Technical Education – When and Why They Choose and Who They Are

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Abstract

The importance of interest for and knowledge in technology and natural science among students can in Sweden be traced in political documents and in media debate. An increased need for female students in technical universities is stressed as well. Higher technical education is facing large dropouts and difficulties, including for female students. This study focuses on the female students who succeed in civil engineering programmes in Sweden, when and why they choose and who they are? Data were collected through a questionnaire sent out to all female students enrolled on civil engineering programmes during term 7 (of 10 terms) in Sweden in 2012. By using the Bourdieu's theory and the concept of capital, the study aims to find out who the female civil engineering student seems to be. In total 411 students answered the questionnaire. The questionnaire answers were analysed with SPSS both for descriptions (frequencies and cross tabulation) and classification (cluster analysis) and the aim was to detect different patterns within the material. From the material it is possible to describe the majority of female students on civil engineering programmes, but also to detect four different female student profiles. The research questions will be answered by analysing and discussing patterns detected in the questionnaire answers.

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Keywords: higher education; technology education; engineering education; gender aspects within technology education

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1. Introduction

In Sweden, as in other countries, widespread attempts are under way to improve the numbers of people studying and working in technology, science and engineering (BIS, 2009; SOU 2010:28; OSTP 2010). Every year in Sweden there are about 10,000-12,000 applications for about 6500-7700 Master of Engineering university places. In total, Master of Science in Engineering courses (civil engineering programmes) are available at 11-14 universities with different variants (about 40-50 different specialisations). Every year about 50-55% of the students take their examinations, which indicate a high level of dropouts. For example, evaluations show a higher completion rate for students with parents with a higher level of education (UKÄ, 2013). One explanation for the high level of dropouts is the problems that Swedish pupils seem to have with mathematics, according to politicians emphasising concerns over the PISA (2013) results within mathematics and science. About 70-75% of the students are male and about 25-30% female.

Research shows that most young people (aged up to 16) actually like technology but do not see the professions of scientist or civil engineer as possible desirable careers (ASPIRES, 2013), and the compulsory school system does not seem to inspire young people to choose a career in engineering (Swedish Schools Inspectorate, 2014). The students who see such a future for themselves seem to have more science capital within their families, such as science-related qualifications, knowledge, interest, literacy and contacts (ASPIRES, 2013).

Research also shows that students who succeed in their civil engineering education have been able to achieve a kind of "engineering literacy" including ways of reading, writing, speaking, using models and tools, behaving, interacting, believing, displaying a particular world view etc. (Allie et al., 2009) but also applying some strategies that help them manage the "gap" that occurs in the complex and social process of making the transition from secondary school to engineering in higher education (Tolstrup Holmegaard et al., 2013). For example, the students change their own focus of technical interest or make more of social integration into the programme (ibid).

Examples of factors for academic success that affect engineering students seem to be visualisation ability and an extrovert personality that makes them enjoy learning through problem-based approaches in social contexts (Burton & Dowling, 2009).

One difficulty that occurs in research and explains dropouts is the issue of how a student identifies with the engineer role; the institution "offers a very narrowly defined range of successful identities, and it is likely that many students do not find an identity that fits" (Allie et al., 2009)., Students perceive science, technology, engineering and mathematics (STEM) as "stable, rigid and fixed" and hence a narrow platform for developing desirable identities (Tolstrup Holmegaard et al., 2012).

Female students seem to have concerns about the engineering role and, for example, adopt a "resistance" identity, asserting their difference from other females and "claimed" to be "more like boys" (Walker, 2001, p.86).

In the early 1960s with a more highlighted technology education within Sweden, the female engineer came to be seen as a symbol for modern Sweden (Hedlin, 2011) but still in the 1990s, Staberg (1994) found that girls had negative experiences of technology education within lower secondary school and the same result recurs in evaluations in 2014 (Swedish Schools Inspectorate, 2014) being viewed as one explanation of the low percentage of female engineering students.

Other examples are female students who express science and engineering aspirations as a possibility and who describe themselves as "not girly", while they are described by teachers and parents as good, nice and focused on academic achievement (Archer et al., 2012). But there also seem to be a smaller number of female students who balance science and technology interests with a more "girly" identity. They are described as sociable, fashionable and sporty (Ibid.).

About 25-30% of the civil engineering students in Sweden are female. For example in the academic year 2009/2010, 1983 female students started civil engineering programmes (29% women). If they follow their courses according to plan they will receive their degrees in 2014. As a comparison, 823 female students did receive their degrees in 2012 and 970 in 2013.

2. Aim of the investigation

This study focuses on the female students who succeed in engineering programmes in Sweden. It is interesting to investigate when and why they choose their programmes and specialisations, how they succeed and who they are. I am interested in why female students choose to become engineers, what has inspired them and how they identify with the engineering role. With such results it might be possible to understand how, when and in what way within the educational system young people could be inspired to choose higher education in technology.

3. Research questions

With this as a background, the following research questions were formulated:

- When and why do Swedish female students choose engineering programmes?
- How do Swedish female students succeed in engineering programmes?
- Who are they?

4. Theoretical framework

By using Bourdieu's theory and the concept of capital, the study aims to find out who the female civil engineering student is. "Capital" in this context means different recourses and experiences (social, educational, economic etc.) in a person's life. Bourdieu's theory can be used to describe the capitals, attitudes and views that students possess which mean that they fit in and succeed in their studies. Various capitals develop value both in the relationship between individuals in a social practice, such as different civil engineering programmes, and in relation to the overall power structure in society various capitals develops its value (Bourdieu, 2004). Based on the background and theoretical framework described above, the study attempts to find the characteristics and attitudes that mean that the student fits in as a female student in an engineering programme in Sweden; both how she makes choices and how she identifies herself within the role but also the female student's life: social background, lifestyles, interests, taste. All aspects combine to produce the basis of an analysis about what seems to emerge as "typical" and symbolic capitals (highly valued characteristics and experiences that mean that one "fits in" and succeeds according to Bourdieu (1984)). Such framework could give a deeper analysis and underlying findings within the field of engineering education.

5. Methodology

5.1. Data collection

A web-based questionnaire was constructed with a total of 148 statements (structured into 50 questions) based on background aspects such as programme, university, age, earlier education, parents' educational level, parents' professions etc., but also based on aspects relating to the choice of programme, plans after taking the degree, identification with the role of engineer and success factors. The questionnaire also included statements about the student's interests and activities outside university and issues related to how the student describe their personality. The questionnaire was created within the theoretical framework and based on Bourdieu (1984) plus related studies and other studies based on questionnaires dealing with the same topic, such as the Norwegian project ViljeConValg, 2014.

Statistical data from the SCB (Statistics Sweden) has also been used for the analyses; data such as engineering programme and specialisation, credits and grades in mathematics from compulsory school, place of residence during compulsory school, parents' educational level.

This questionnaire was then sent out to all female students enrolled on engineering programmes in term 7 (of 10 terms) across Sweden in September 2012; in total about 1200 students (80% were contacted via an e-mail including the link to the questionnaire, 20% via a paper letter presenting the link to the web-based questionnaire). In total 411 students answered the questionnaire (375 from the e-mail group and 36 from the letter group). These 411 female students are potentially nearly half of the group of female students that will take their examinations in spring 2014.

Statistical data from SCB, described above, exist for 641 of the 1200 female students, giving the opportunity to investigate characteristics for a slightly larger group.

5.2 Analysis methods

The answers to the questionnaire were analysed with SPSS (Statistical Package for the Social Sciences) both for descriptions (frequencies and cross tables) and classification (using cluster analysis: hierarchical, Ward's method, Euclidean distance), the aim being to detect a variety of patterns within the material. The material makes it possible to find a description of the majority of female students on civil engineering programmes but also to find a number of profiles for female students.

Within the cluster analysis, the clustering was based on answers to three specific statements/variables (whether they were inspired by parents working as engineers, inspired by parents who were not engineers and whether the topics on the courses were really interesting or not) and four clusters were created. This clustering is thereby partly in agreement with results from earlier research that show how parental education and occupations would play a role in Swedish students' choice of upper secondary and higher education (for example Broady et al., 2009).

The study has within its analysis both a variable-oriented approach and a person-oriented approach (Sjöquist et al., 2010; Bergman et al., 2003). When using results from frequencies and cross-tables, it is possibly to create a variable-oriented analysis in which variables could be compared on group level.

Using cluster analysis is an example of a more person-oriented approach. Within a person-oriented approach, the focus is on individuals and how the complexity created by different variables taken as a whole can describe the individuals' situation and characteristics. A person-oriented approach could give a better understanding of how individuals function. Individuals could be presented in different profile groups in which each profile has its own specific properties.

Variable-orientation and person-orientation produce different results. Variable-orientation deals with relationships between different variables and person-orientation handles individuals and the specific patterns that emerge on the specific system level being investigated. The two approaches must, however, be seen as complementary rather than conflicting (Bergman et al., 2003).

As a combination between a variable-orientation and a more person-orientation, a profiling has been made from one specific question/variable: *when did you decide to be an engineer?* In this question there were 7 different options and out of the students' answers, 3 different groups has been formed: (1) I decided within compulsory school (with age 7-15), (2) I decided within upper secondary school (with age 16-18) and (3) I decided after upper secondary school (older than 18). Thereafter, a cross-tabulation has been made with all 3 groups against all the other variables (147 statements) which made a result emerge with 3 different profiles based on when the student decided to be an engineer. This specific question is interesting to highlight in relation to the educational system and how a technology education within compulsory school and upper secondary school develop pupils interest for higher education in technology or not.

The result presents descriptions based on three different structures with aim to find patterns. The research questions will be answered by analysing and discussing patterns found in the answers from the questionnaire.

5.3 Authenticity, reliability and validity

The authenticity and plausibility of the data must be considered, especially for interpretive research methods (Walsham, 2006) as well as the prior understanding of both the researcher and readers of the study. When sending out a questionnaire it is important to reflect on what the respondent may choose to give as an answer that will be a ground for a result. However, there is no reason to believe that students would not honestly answer the questions posed. Questions concerning study success factors, whether they have employment in addition to their studies, how they perceive the severity of their studies etc. are not personal or hard to answer. And some variables such as engineering programme, specialisation, parents' education and occupation etc. have also been compared with statistics from Statistics Sweden.

When considering cluster analysis, is it important to remember that a cluster is only a crowd of people clustered together and that it is only based on the fact that they have given the same answer to particular predefined questions. It is important not to over interpret what a cluster group stands for.

Statistics relating to the students' choice of university, specialisation relating to parental occupation and education may be seen as valid descriptions. When other answers are analysed in relation to statistics and this in turn is connected to previous research, it is then possible to draw general conclusions as this also includes a relatively large number of respondents.

6. Results

6.1. Some general variable-oriented results

Most of these women were 19-21 years old when they started their studies and most of them have chosen a university with a good reputation. Over 60% want to obtain employment as an engineer within the Swedish private sector; very few in the private sector abroad. At least half of them are to some extent engaged with student associations, and many of them seem to classify their studies as being challenging. They don't seem to have employment alongside their studies; only a few of them work, for 2-10 hours per week or less. Many seem to live in a rented apartment, fewer in student corridors or in shared apartments.

None of the students seem to have been inspired to embark upon higher education in technology by teachers during earlier years in compulsory school or by the teaching or teaching material employed there. All students answer the question about how they identify with an engineering role by saying it means doing something good in their professional life and that it provides great variety. They have a facility for mathematics which was both a reason for choosing technical higher education and a factor for success. Nearly all of the students answer that the best strategies for learning are to quickly understand complex issues or that succeeding with comprehensive, intensive reading and lectures is the best learning method, and also traditional classroom teaching or project work. One success factor mentioned is having fun alongside their studies but also fellowship with other students.

Most of this group exercise in their spare time. They eat meat, but don't watch football, do the lottery, smoke or use snuff. Nor do they visit the opera or classical concerts. They like to meet their friends, they use public transport but do not associate with their neighbours, demonstrate, buy shares or go fishing. Nor do they hunt, write poetry, believe in God or participate in live role playing, theatrical performances etc.

SCB statistics contain data from about 641 female students from the current set of engineering programmes, which is approximately half of all female students. From these statistics, it can be seen that most of these students had the highest ratings in mathematics in lower secondary school (grade MVG), fewer had the next highest grade (grade VG) and very few, only 2%, had a lower mark (grade G). Most of the female students' mothers have a long university education (4-5 years or longer) and their fathers also seem to be well-educated.

*6.2. 3 profiles based on the variable **when** the student decided to be an engineer*

Those who decided early to become an engineer (1)

Many of these students took natural science program in upper secondary school and they have a great interest for natural science and mathematics. Most of them have chosen a university with good reputation. More of them have chosen Technical physics as specialisation. Their mothers have university education or more (doctor grade) and more of them have also fathers with university education or more (doctor grade), many of the students also have at least one parent with a degree in technology. More of these students became inspired to the choice of program by parents, who are engineers. More of these students have for example a mother that is an engineer. Most of them find mathematics to be easy, which both has become a reason for choosing technical higher education and a factor for success. Many of them have also felt for a long time that they will fit in as an engineer and more of these students answer that they want a profession that will provide a job with many opportunities. Many of these students answer that one factor for success is that it has been fun besides their studies and more of them find their studies very challenging. Many of them find that the best strategies for learning is to quickly understand complex issues or managing comprehensive, intensive reading. More of these students find it important with a teaching content

relevant for the future occupation and many seem to think that lectures is the best learning method and also traditional classroom teaching or project work.

Those who decided within upper secondary school (2)

Many of these students also took natural science program in upper secondary school and they also have a great interest for natural science and mathematics. They have as well chosen university with good reputation but more of them have chosen Industrial economics as specialisation. Their mothers also have university education or more (doctor grade) but fewer of them have fathers with university education or more (doctor grade), many of these students have also at least one parent with a degree in technology. More of these students want a profession that makes it possible to earn a lot of money and more of these students have a father that is technician. Most of them find mathematics to be easy, which has become a reason for choosing technical higher education but they do not stress it as a factor for success. Many of them answer that they want a profession that will provide a job and many of these students answer that one factor of success is the fellowship with other students and more of them finds their studies challenging. Many of them as well find the best strategies for learning is to quickly understand complex issues or managing comprehensive, intensive reading. Fewer of these students find it important with teaching content relevant for the future occupation. Many of them finds lectures or project work to be the best learning method but fewer traditional classroom teaching.

Those who decided after upper secondary school (3)

Fewer of these students took natural science program in upper secondary school and fewer seem to have a great interest for natural science and mathematics. Many of these students also have chosen university with good reputation but more of them have chosen Biotechnology as specialisation. Their mothers have university education or more (doctor grade) as well and many of them have fathers with university education or more (doctor grade). Fewer of these students have at least one parent with a degree in technology but more of them have mothers that are teachers or nurses. More of these students have been inspired by engineering friends and more of them answer that they want a profession that will provide a job but they also want a profession with many opportunities which gives possibilities to do good for the society, the humanity or do something good for the environment. Many of them find mathematics to be easy, which has become a reason for choosing technical higher education but they do not stress it as a factor for success. More of these students answer that one factor for success is the fellowship with other students and more of them finds their studies challenging. Many of them find that the best strategies for learning is to quickly understand complex issues or managing comprehensive, intensive reading. Fewer of these students finds it important with teaching content relevant for their future occupation but many of them finds that lectures or project work to be the best learning method and more of them finds also traditional classroom teaching as a good method for learning.

6.3. 4 students profiles based on cluster analyses

From the cluster analyses, four different student profiles emerged.

Student profile (1) is entitled *the More of life experiences group* and includes 127 students with well-educated parents, such as teachers. More of these students have chosen biotechnology as their programme specialisation compared with the other profiles. These students are characterised by having made their choice after upper secondary school or after a period within higher education in some other programme, but a few also made their choice of programme when they made their applications. Slightly more of these students than the other profile groups have travelled for an extended period during a study break after upper secondary school and slightly fewer of them say that they were inspired by teachers in upper secondary school. To a large extent, compared to the other cluster profiles, these individuals emphasise that they want to do something good for society and humanity, but they do not consider the aim of graduating as an engineer, that the course suits them or that they seem to feel comfortable with their choice to be inspirational in succeeding in their studies.

A profile emerges here that identifies with an engineer role that has the opportunity to do something good for humanity, society and the environment. But the students still have doubts about whether the profession is actually

the right one for them, even though they are aware of the range of possibilities within the engineer role and that these possibilities occur in different fields.

Student profile (2) is entitled the *More of engineer capital group*, and includes 59 students who specifically have parents who are engineers. More of these students have chosen technical physics as a programme specialisation, and they tend to have made their decision about their profession over a longer period of time. More of them have chosen a university with a good reputation and have attended primary school and/or upper secondary school abroad. A few more of these students have taken the natural science programme within upper secondary school and more of them want to work as an engineer abroad. They have not been inspired by teachers or schoolwork in compulsory school and only a few of them have been inspired by teachers within upper secondary school; they have always thought that they would become an engineer and they have, for example, a facility for mathematics that has encouraged this intention. In comparison with other clusters, this group is characterised by wanting to take a course that provides jobs and a profession with many opportunities. Many of them have been supported within their studies by parents and siblings; having some fun alongside their studies has been a factor for success and they want to do something good in their professional life. All of them have well educated parents, who have, for example, held posts within the faculty etc., and they all appreciate the traditions at the university and consider that their studies are very demanding. They do not have any employment and some of them live at home with their parents.

The profile identifies with an engineer role that provides many opportunities and possibilities to create benefits for society; the students simply consider "engineer" to be a good profession. Important strategies for succeeding with their studies are, for example, to be involved in a lot of social activities and to develop to be part of the "culture".

Student profile (3) is entitled the *More of educational capital group*, and includes 95 students who have parents who are not specifically engineers but who are also well-educated. More of this group have chosen industrial economics as a programme specialisation. They have always had a facility for mathematics and many of them decided to become an engineer after completing upper secondary school, although some of them made this choice early in upper secondary school. Slightly more of them have chosen a university close to home and are also interested in working as an engineer in the private sector in Sweden. Slightly more of the students with this profile have been inspired by friends who are engineers or engineering students but some of them also by teachers in compulsory school. Compared with the other clusters, these students are characterised by wanting a profession that provides jobs, and with many possibilities. They mention facility for mathematics as a success factor, they quickly got to grips with their studies and then found it easy to continue. They seem not to have time to read anything other than course literature.

This profile identifies with an engineer role that is successful within any kind of sector. This student is ambitious and performs well in her studies. She succeeds in her course by applying good study technique and great self-confidence in relation to education.

Student profile (4) is entitled the *More of natural science capital group*, and includes 130 students. They specifically answer that they really enjoy and like the course objectives and content. Many of them have chosen industrial economy or biotechnology but also technical chemistry as specialisations. More of these students chose their field of study as early as lower secondary school and a few more have taken their elementary upper secondary schooling abroad. Slightly fewer of this group took the natural science programme in high school, instead studying the technology programme or International Baccalaureate (IB). From early childhood they have always been interested in natural science and mathematics and more of them have siblings who are engineers. But they seem to have fewer friends that are engineers. This group is characterised by people who really want to work as an engineer. They want to earn good money, but they are not as concerned about doing good things for society and mankind or about working with environmental issues. They state that they found mathematics easy and that their choice has always felt entirely right. Being an engineer, according to these students, means being creative and coming up with things, and they want to solve problems and do research.

A profile emerges here of a student who within her studies is driven by a strong interest in natural science and a desire to work as an engineer or in any related field of science and technology; one who has always known that this is possible. She identifies with an engineer's role as a creative problem solver and a researcher.

7. Discussion

According to Pierre Bourdieu (1996) individuals strive to preserve and increase their capital within the fields that they come to operate in. When students choose, and study within, technical higher education, specific capital seems to be important and useful:

- A view of higher technical education as a pathway to something "for me".
- A positive view of the engineer role and an understanding that such a role has many faces.
- A positive view of lectures and classroom teaching and an opinion developed throughout the whole educational system about how effective such teaching will be.
- Great self-confidence in mathematics throughout school and awareness of how mathematics can be a tool for pathways through higher education.
- An interest in natural science from childhood and a knowledge that such an interest could be used in a diversity of technical areas and thereby in professions, not merely connected to fun experiences at a science centre or short-lived activities and experiments within natural science and technology education.

They have well-educated parents, and many of them even have parents with a technical background. They have a positive attitude to the profession of engineer and enjoy the typical traditions at the technical universities. They have found like-minded friends and seem to be aware that their aptitudes, especially for mathematics but also for natural science, give them success. They truly fit in and embrace the traditions in terms of both the educational and social aspects of their courses.

Both the variable-oriented analysis and the more person-oriented cluster analysis show that female students who have success in engineering programmes are characterised by their possession of certain capital. There is thus a reproduction of traditional patterns. Children of educated people, often engineers, are provided with an obvious choice through the capital they possess. They choose traditional universities and like and maintain "roles" and "culture". These female students "fit in" and are daughters of educated parents, often in technology, and specifically of highly educated mothers.

The culture and roles are thereby preserved. These active and successful forms of capital do not seem to come from earlier schooling within the compulsory and upper secondary school systems, but instead to a greater degree from the student's home conditions. Earlier education may help to reinforce this capital, with students who already have suitable forms of capital as a result of their home background feeling even more reinforced.

8. Conclusions and implications

One conclusion from the results is that, to a great extent, female students in higher technical education in Sweden represent a homogeneous group and that their interest and strategies for succeeding in higher education seem not have been established within lower years in school or stimulated by teachers there. Fruitful capital and successful strategies can instead be connected to social background and parental levels of education.

One implication is that compulsory schooling, especially the lower upper secondary level, must take more responsibility for making technology a subject that could be seen as relevant for girls with different social backgrounds, interests and lifestyles, if we really want more than 25-30% girls within higher technical education courses. It is likewise appropriate that teaching in primary schools and even in the natural science programme at upper secondary school level should reveal what it means to have a career as an engineer and how higher education within engineering can function and be successfully completed. Examples could be that getting mentors for female students and involving parents in the education, so they may provide needed support etc.

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